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THE UNIVERSITY OF ALBERTA

THE RELATION BETWEEN PROBLEM SOLVING ABILITY IN GRADE V. ARITHMETIC AND EACH OF THE VARIABLES SEX, CHRONOLOGICAL AGE AND MENTAL AGE

A DISSERTATION
SUBMITTED TO THE GRADUATE FACULTY
IN CANDIDACY FOR THE DEGREE OF
MASTER OF ARTS

DEPARTMENT OF PHILOSOPHY

BY

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CHAPTER I

PURPOSE OF THE INVESTIGATION

This investigation is an attempt to determine the relation existing between the variables: sex, chronological age and mental age, of Grade V. students, and their ability at problem solving in Arithmetic. The only criterion of a pupil's arithmetical ability in our schools to-day is the grade. A student in Grade V. is assumed to be intellectually equipped for the solving of questions now on the Grade V. course of studies. No importance is attached to the fact that some pupils are boys, others are girls, some are relatively young, others several years older, some have a high mental rating, others are less fortunate in this respect. Do these differences count for anything? Or since all the students of a given grade have reached that grade at the same time, the younger ones possibly through some degree of acceleration, the older ones owing in many instances to retardation, should they now be judged equally capable of handling the one prescribed sequence of work? It must be remembered that in reaching Grade V. their promotion was largely based on their average work covering several widely different types of learning.

Just what relation actually exists, however, between the ability to solve arithmetical problems, and sex, chronological age and mental age, has not been definitely determined, although much has been done in recent years dealing

with this phase of learning.

Such questions as the following, arise; Have boys greater ability in solving problems in Arithmetic than girls? Taking students of the same mental age, but of different chronological ages, do the younger ones show greater problem solving ability, or has past experience given the older students a better grasp of the actual meaning of the process? These and many other questions of which one might think, may be answered partially by the findings of this investigation.

CHAPTER II

METHOD OF OBTAINING DATA

Distribution of pupils

This investigation was carried out with students in 13 Grade V. rooms in the City of Edmonton. These rooms averaged 33 students, boys and girls, and were chosen from various sections of the city in order to ensure a sampling of pupil material. The distribution of pupils is shown in Table I:

TABLE I

DISTRIBUTION OF GRADE V. CLASSES

School		Teacher	No. Boys	No. Girls	Total
Alex. Taylor	(1)	Miss Wilson	14	14	28
Alex. Taylor	(2)	Miss Dorsay	16	13	29
Garneau		Miss Meldrum	15	16	31
Highlands	(1)	Miss Brown	25	14	39
Highlands	(2)	Miss Alexander	21	19	40
King Edward	(1)	Miss Durrand	21	13	34
King Edward	(2)	Miss Potter	11	20	31
McCauley	(1)	Miss Martin	18	19	37
McCauley	(2)	Miss Thompson	16	17	33
Oliver	(1)	Miss Young	12	17	29
Oliver	(2)	Miss Ravies	15	19	34
Parkdale	(1)	Miss Mill	11	21	32
Parkdale	(2)	Miss Thomas	16	19	35
			211	221	432

All of the above classes were graded as average, none having been composed of pupils of special or inferior ability. It is well known that experience enters largely as a factor in the accomplishments of any pupil. With the selection of pupils from various districts in the city,

the influence of home and social environment will have a tendency to be ironed out.

Three distinct types of data were required from each student, and as these were obtained on different mornings or afternoons, it occasionally happened that a student would answer one or two sets, but be absent for the third. These students were struck from the list and only those remained who had handed in all the required papers. This procedure reduced the number of girls to 217, and the number of boys to 210, a total of 427.

Time of testing.--All tests were given late in October or early in November of 1931. No cognizance was taken of the actual time the individual pupils had attended school, or had been in Grade V.

SETS OF DATA

Three sets of data were obtained:-

(1) Scores on a test consisting of the type of Arithmetic problems usually found in our public schools, known hereafter as "Test A".

(2) Scores on a second type of question paper, aimed to test the reasoning ability of the pupils, and known hereafter as "Test B".

(3) I. Q. rating, obtained from a mental test, known hereafter as "Test C".

Test A.--This test consisted of ten problems of the usual type, arranged in order of increasing difficulty. These were not all typical Grade V. problems. As a matter of fact, they were selected from a large list of problems previously submitted to Grades III. to VII. in Alberta schools, after having been standardized at the School of Education. From some 5000 returns made, these ten problems were selected as representing a scale of steps of equal difficulty. Each mimeographed sheet handed to the pupil contained, in addition to the ten problem questions, spaces for the name of the school, the pupil's name, the sex, and the chronological age,[1] calculated in years and months.

Test B.--This second test consisted of ten problems, arranged in order of increasing difficulty. Instead, however, of aiming to test the purely mechanical application of numbers to problems, the questions presented were of such a nature as to require a carefully thought out, or as it was intended to be, a "reasoned" answer. The many and varied answers on these returns indicated clearly that the pupil was face to face with a new problem, where the simple following of the teacher's earlier directions would not suffice to bring the desired results. The quiz questions on this test had previously been standardized at the School of Education.

---

[1]Hereafter, in this thesis, the term "age" will denote "chronological age", unless otherwise stated.

A copy of each of the preceding tests is appended to this chapter.

Test C.--The mental age of each pupil was based upon the score obtained on the McCall Multi-Mental Test (Elementary School, Form 1.). This scale is recognized as valid and reliable, and while built particularly for pupils in the United States, is,with minor exceptions, quite valuable in the schools of any English speaking country.

Uniformity of Procedure.--It was essential in the giving of these tests in the various classes, that all pupils be placed as nearly as possible, under similar conditions. It was felt that the room teacher should play no part in the testing. Therefore a number of reliable students in attendance at the School of Education, were selected for the task of obtaining the results. The students were given definite and detailed instructions on procedure, and through the co-operation of the City Assistant Superintendent and the City Public School Inspector, were able to carry out the tests in the thirteen selected rooms with a maximum of uniformity. The writer with one assistant marked both sets of answer papers, having previously agreed upon the standard of marking.

The multi-mental test was given in all the classes by Mr. Sullivan, the City Public School Inspector, and also scored by him.

This procedure, it was felt, insured at least an acceptable degree of uniformity.

Difficulty in marking.--Some difficulty was experienced in selecting a proper standard of marking. This was particularly true in the case of the harder and longer problems. A student would carry a process through correctly, but err in the mechanical work. Since it was necessary to mark a question either right or wrong, and not to assign part marks it was agreed to judge the question on the basis of reasoning ability. This method is open to criticism, but it should be noted that relatively few students were thus judged and that these were almost invariably, those who obtained the greatest number of correct solutions.

TEST A

SCHOOL_____ NAME_____

GRADES 3, 4, 5, 6 and 7 SEX_____

AGE: YEARS_____ MONTHS_____

No. 1 There are 30 days in June and 31 in July. How many days are there in the two months?

No. 2 How many pints are there in 7 quarts?

No. 3 How many inches are there in 1/3 of a yard?

No. 4 In four days a carpenter worked 10 hours, 7 hours, 8 hours and 9 hours. How much did he earn at 45 cents an hour?

No. 5 A farmer raised 26 bushels of wheat per acre on 49 acres. How much is it worth at $1.12 per bushel?

No. 6 A man buys ice cream at $1.20 a gallon. From each quart he serves five dishes at 10 cents a dish. What is his profit on 1 gallon of ice cream?

No. 7 A boy can run 100 yards in 12 seconds. How far would he run in an hour if he could keep running this fast?

No. 8 How many square yards of pavement are there in a street ¼ mile long and 66 feet wide?

No. 9 If $12\frac{3}{4}$ tons of coal cost $84.00, how much coal could I buy for $16.00?

No. 10 A man's income is $2520 per year. He pays an income tax of $4\frac{1}{2}$ per cent on the part ofhis income that is over $2000. Find the amount of his income tax.

On the question sheets submitted to the pupils sufficient space was left after each question for a written solution.

TEST B

SCHOOL_____ NAME_____

GRADE_____ SEX_____

AGE: YEARS_____MONTHS____

Test OT 3456

1. A man bought 225 sheep at $9 each. He sold 90 of them at $12 each. If you subtract 90 from 225 you get 135. What does this 135 tell you?

---

2. $5 for 3 days equals $15 for_____days.

---

3. You know the cost of a box of oranges. You know how many oranges there are in the box. How can you find the cost of an orange?

---

4. If there are 2 lento in 1 mal, how many mal are equal to 5 lento?

---

5. If you know how much a man earns in seven days, how can you find how much he earns in one day?

---

6. Mary is reading a book that has 100 pages. She has read 60 pages. This line_____shows how many pages are in the book. Draw a line to show how many pages she has to read yet.

---

7. Write a problem with two numbers in it that should be multiplied to give the answer.

---

8. Work of 10 men in 4 days equals work of_____men in 2 days.

---

9. You are given these three facts:
Fact 1: There are 6 books on the table.
Fact 2: Each book has 45 pages.
Fact 3: There are 150 words on each page.

To find how many words there are in a book, you would use facts 2 and 3.

Which facts would you use to find how many pages there are in the 6 books?

---

10. In the next question another bit of information is needed before you can answer the question asked. On the dotted lines tell what else you must know before you can answer the question.

Question	Things You Must Know
What is the value of the total wheat crop?	(a) The price of the wheat per bushel. (b) The number of acres of wheat. (c) _____

MULTI-MENTAL SCORING STENCIL

Elementary School
Form 1

ary School
rm 1

1. Cut along the dotted lines. Then place stencil over pupil's test paper.
2. Add mentally the credits earned in each row, and write total in the square at the right.
3. Pay no attention to unmarked word-groups, except to place a check for each such group that is skipped in the right hand margin of the pupil's paper. When two or more words in a group are marked, score the mark the pupil intended as final. When his intent is not clear, treat the group as unmarked, and make a check in the margin.
4. Total the credits in the ten squares, and write the sum after the word *Total.*
5. Multiply by five the number of groups actually marked and scorable, and subtract from *Total* to get *Score.* If *Score* is negative, prefix a minus.
6. Convert this *Score* into G, T, or mental age, as desired, by means of table given in MULTI-MENTAL MANUAL.

1	2	3	4	5	6	7	8	9	10
10	2	5	9	10	0	5	1	1	8
9	0	0	2	1	4	0	5	3	0
3	0	1	9	3	10	10	0	0	2
0	10	10	10	0	3	9	4	10	10
1	3	9	0	2	1	4	10	0	3
9	10	10	5	6	5	10	0	0	10
4	6	3	7	10	0	2	4	3	5
0	0	0	0	4	4	6	0	9	0
10	5	10	10	6	10	0	10	10	6
3	5	2	3	0	0	5	2	1	6
2	0	10	3	5	2	7	1	10	0
10	0	0	1	7	0	10	10	7	4
2	10	5	10	0	5	0	5	0	0
6	8	9	0	10	10	1	2	1	1
0	3	0	1	5	3	6	0	1	10
4	9	0	8	7	10	4	10	5	10
10	5	9	10	0	3	0	0	0	4
5	9	7	1	10	0	10	4	1	1
7	10	10	7	9	9	3	5	10	6
0	0	1	0	2	2	1	1	2	0
10	7	10	10	0	0	5	7	9	10
2	3	4	5	5	10	10	0	2	0
3	4	6	6	9	1	0	10	0	1
0	10	6	6	10	7	2	7	10	1
8	0	0	0	2	3	3	1	6	2

51	52	53	54	55	56	57	58	59	60
8	10	10	10	9	6	4	4	0	5
0	6	3	7	2	2	3	0	1	10
1	4	10	8	10	0	2	10	7	0
10	7	8	3	7	10	10	9	9	2
1	0	0	0	0	2	0	6	10	1
0	10	3	0	4	8	5	0	2	0
4	8	1	8	10	8	10	4	7	4
1	1	10	2	0	2	7	2	0	10
2	2	8	10	4	0	0	1	8	2
10	0	0	1	6	10	2	10	10	0
8	5	10	8	6	10	5	10	0	5
6	5	1	5	10	9	0	5	3	0
10	6	1	10	0	0	10	0	5	7
0	10	4	0	3	8	0	8	10	10
4	0	0	3	5	1	3	1	1	5
0	0	10	4	8	9	6	5	0	0
10	10	2	9	10	2	10	3	4	2
0	7	3	10	0	2	1	1	10	1
6	4	0	5	4	0	0	10	6	10
6	3	0	0	1	10	1	0	7	2
0	1	0	5	8	0	5	8	10	10
10	5	7	2	2	6	0	5	0	0
4	0	8	5	0	10	10	10	3	7
4	10	10	0	8	3	5	5	10	4
0	8	3	10	10	7	1	0	4	3

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Total	
Minus	
Score	

MULTI-MENTAL SCORING STENCIL

Elementary School
Form 1

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rm 1

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6. Convert this *Score* into G, T, or mental age, as desired, by means of table given in MULTI-MENTAL MANUAL.

	1		2		3		4		5		6		7		8		9		10	
10	fly	2	cup	5	horse	9	lesson	10	grass	0	robin	5	high	1	irriga	1	black	8	word	
9	burn	0	fork	0	calf	2	proble	1	coal	4	gerani	0	low	5	land	3	hot	0	paragraph	
3	gasoli	0	sauce	1	colt	9	teache	3	carbo	10	elepha	10	cat	0	soil	0	white	2	sentence	
0	coal	10	bowl	10	hen	10	learn	0	tar	3	poppy	9	fever	4	cultiv	10	star	10	style	
1	wood	3	knife	9	cow	0	solve	2	soot	1	blueb	4	dange	10	navig	0	cold	3	composition	
	11		**12**		**13**		**14**		**15**		**16**		**17**		**18**		**19**		**20**	
9	baby	10	anoth	10	cruel	5	vote	6	foreig	5	gold	10	moon	0	stone	0	needle	10	quickly	
4	slow	6	first	3	cheer	7	decide	10	brave	0	steel	2	seed	4	wood	3	scisso	5	buy	
0	donke	0	either	0	court	0	citize	4	rose	4	ore	6	tree	0	iron	9	paper	0	manufacture	
10	gate	5	last	10	lad	10	factor	6	coin	10	spring	0	root	10	horse	10	cloth	6	shoes	
3	sleepy	5	neith	2	gener	3	juries	0	fragr	0	iron	5	saplir	2	clay	1	threa	6	sell	
	21		**22**		**23**		**24**		**25**		**26**		**27**		**28**		**29**		**30**	
2	lesson	0	grapes	10	cloud	3	mine	5	wind	2	stock	7	violin	1	murm	10	fence	0	Washington	
10	holida	0	plums	0	excite	1	water	7	blows	0	shirt	10	flute	10	smile	7	rock	4	Lee	
2	study	10	peach	5	water	10	cap	0	lightr	5	mend	0	guita	5	brook	0	lime	0	Grant	
6	learn	8	raisin	9	runni	0	lake	10	thunc	10	head	1	manc	2	babbl	1	morta	1	Lincoln	
0	recite	3	prune	0	crowc	1	iron	5	flashe	3	coat	6	banjc	0	spark	1	wall	10	Edison	
	31		**32**		**33**		**34**		**35**		**36**		**37**		**38**		**39**		**40**	
4	half	9	selfish	0	in	8	desk	7	flock	10	bird	4	drum	10	cat	5	eye	10	speed	
10	seven	5	sincer	9	out	10	teach	0	cattle	3	swim	0	lesso	0	bird	0	nose	4	interest	
5	nickel	9	man	7	on	1	pew	10	barn	0	crawl	10	sharp	4	fins	1	chin	1	legislature	
7	quart	10	kind	10	up	7	schoo	9	geese	9	fish	3	beat	5	fly	10	hand	6	money	
0	dime	0	gener	1	under	0	churc	2	herd	2	snake	1	studi	1	fish	2	ear	0	laws	
	41		**42**		**43**		**44**		**45**		**46**		**47**		**48**		**49**		**50**	
10	chair	7	tire	10	come	10	sheep	0	write	0	pulp	5	baby	7	moth	9	knife	10	barometer	
2	letter	3	engine	4	cube	5	rose	5	read	10	knife	10	boy	0	stude	2	sword	0	government	
3	books	4	horn	6	edge	6	busy	9	book	1	bark	0	man	10	book	0	dagge	1	establish	
0	poem	10	mast	6	face	6	beaut	10	house	7	root	2	work	7	teach	10	shield	1	investigate	
8	write	0	wheel	0	squar	0	bee	2	letter	3	leave	3	cries	1	daug	6	saber	2	criticize	
	51		**52**		**53**		**54**		**55**		**56**		**57**		**58**		**59**		**60**	
8	hat	10	fruit	10	rain	10	lines	9	arrow	6	brick	4	owns	4	elect	0	boy	5	gasoline	
0	kind	6	made	3	snow	7	draw	2	pointe	2	frame	3	sells	0	presic	1	girl	10	wagon	
1	cheer	4	money	10	storm	8	coinci	10	sticky	0	concr	2	house	10	king	7	kitten	0	streetcar	
10	quick	7	bread	8	wind	3	points	7	swift	10	silver	10	sits	9	appo	9	run	2	auto	
1	boy	0	gave	0	hail	0	angles	0	straigh	2	house	0	buys	6	secret	10	apple	1	electricity	
	61		**62**		**63**		**64**		**65**		**66**		**67**		**68**		**69**		**70**	
0	door	10	floor	3	perfun	0	nation	4	man	8	lazy	5	cat	0	pictu	2	corn	0	automobile	
4	lamp	8	woma	1	fragra	8	senate	10	horse	8	light	10	bird	4	wall	7	whea	4	aeroplane	
1	knob	1	smoke	10	tropic	2	count	0	rooste	2	idle	7	stone	2	horse	0	muffi	10	furnace	
2	table	2	engine	8	rare	10	villag	4	woma	0	heavy	0	parro	1	carria	8	biscu	2	radio	
10	boy	0	men	0	flower	1	state	6	hen	10	busy	2	feed	10	bug	10	sausa	0	telephone	
	71		**72**		**73**		**74**		**75**		**76**		**77**		**78**		**79**		**80**	
8	leaf	5	circle	10	dance	8	boy	6	air	10	runs	5	knife	10	army	0	tell	5	perseverance	
6	root	5	cube	1	bear	5	barks	10	earth	9	rabbi	0	sauce	5	camp	3	langu	0	faithfulness	
10	grou	6	area	1	beaver	10	black	0	water	0	dog	10	spoon	0	scout	5	story	7	honesty	
0	stem	10	acre	4	hunt	0	dog	3	fish	8	jump	0	fork	8	row	10	well	10	conflagration	
4	flowe	0	triang	0	fight	3	plays	5	bird	1	barks	3	cup	1	hike	1	speak	5	courage	
	81		**82**		**83**		**84**		**85**		**86**		**87**		**88**		**89**		**90**	
0	sour	0	gun	10	like	4	paper	8	large	9	cat	6	wrong	5	swim	0	churn	0	Alaska	
10	sweet	10	hamm	2	nation	9	cover	10	air	2	monk	10	give	3	spide	4	sew	2	Mexico	
0	bitte	7	sharp	3	positio	10	door	0	white	2	baboc	1	right	1	fish	10	write	1	United States	
6	acid	4	shoot	0	rule	5	book	4	ball	0	tiger	0	night	10	lamb	6	butte	10	France	
6	tart	3	knife	0	accept	0	leathe	1	hard	10	elepha	1	sleep	0	spin	7	dress	2	Canada	
	91		**92**		**93**		**94**		**95**		**96**		**97**		**98**		**99**		**100**	
0	eat	1	books	0	wool	5	sweet	8	chair	0	smoo	5	girl	8	duck	10	baby	10	investigate	
10	sing	5	power	7	cloth	2	lemor	2	room	6	road	0	walk	5	padd	0	pupp	0	publish	
4	book	0	knowl	8	shoes	5	cake	0	hall	10	great	10	does	10	gees	3	kitter	7	editors	
4	appl	10	paper	10	meat	0	sour	8	buildi	3	rough	5	sleep	5	fish	10	pig	4	write	
0	read	8	food	3	leathe	10	salty	10	door	7	table	1	play	0	swim	4	calf	3	printing	

Total	
Minus	
Score	

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CHAPTER III

SUMMARY OF DATA

Results Obtained

As has been stated previously, the problems in each of the two tests given were graded in order of increasing difficulty. Owing to the fact that some of the more difficult problems in Test A required certain mechanical knowledge for their successful completion, these really lay beyond the range of the average Grade V. pupil. While this fact reduced the possible number of successful answers for the average student, it does not invalidate the comparisons to be made later.

Test B, on the other hand, was composed entirely of problems well within the mental reach of a considerable number of Grade V. Pupils, as is evidenced by the results shown below.

TABLE II

SUMMARY OF RESULTS OBTAINED ON TESTS

Test A

Prob.	1	2	3	4	5	6	7	8	9	10
Boys	206	196	130	132	73	93	26	1	0	0
Girls	214	192	129	144	61	80	15	1	0	0
Total	420	388	259	276	134	173	41	2	0	0

Test B

Prob.	1	2	3	4	5	6	7	8	9	10
Boys	141	119	41	126	83	58	73	62	41	48
Girls	134	140	32	96	64	86	98	44	48	35
Total	275	259	73	222	147	144	171	106	89	83

Classification of Pupils by Age and I. Q.

A summary based on chronological age and I. Q. is shown in Table III.

TABLE III

CLASSIFICATION OF PUPILS BY SEX, AGE AND I. Q.

BOYS

I. Q.	Age 9	10	11	12	13	14	15	Total
-94	0	1	13	27	17	9	1	68
95-105	0	15	46	13	2	0	0	76
106-	3	34	25	3	1	0	0	66
Total	3	50	84	43	20	9	1	210

GIRLS

I. Q.	Age 9	10	11	12	13	14	15	Total
-94	0	1	14	28	7	0	3	53
95-105	0	24	33	8	2	0	0	67
106-	10	54	30	2	1	0	0	97
Total	10	79	77	38	10	0	3	217

Throughout this thesis, for purposes of convenience, mental age has been transferred into intelligence quotient (I. Q.), by dividing the mental age by the chronological age, each being computed in years and months. This was found to be quite a satisfactory procedure, without altering final conclusions. The preceding table gives the classification of each sex by age (taken to the nearest birthday) and I. Q. The group 95 to 105 was chosen as representative of the truly

normal student and was found to contain approximately one-third of the total number of students.

The ranges indicated in Table III. verify our previous statement that these are average Grade V. classes with the majority of pupils centering around 11 years of age, as it should be in the Alberta system. This is due to the fact that the normal age of entrance into Grade I. is 6½ years, making 10½ years the theoretical entrance age into Grade V. This age is slightly raised as a result of retardations in the lower grades, bringing the normal age to 11 years. The older pupils of both sexes are of lower I. Q., while those with the higher I. Q. are the younger set. A comparison of the table shows a larger percentage of young girls than young boys, and a correspondingly greater percentage of older boys than older girls.

TABLE IV

AVERAGE SCORE BASED ON AGE

	Test	Age 10	11	12	13
Boys	A	4.16	4.20	3.60	3.82
	B	4.06	3.70	3.80	2.76
Girls	A	3.68	3.88	3.42	4.00
	B	3.44	3.69	3.20	3.30

The above figures reveal a number of interesting facts. It will be noted that the age of 12 years

shows a decided drop in ability in both types of questions, with a slight exception in the boys' Test B results.

Secondly, while the average number of correct solutions in each type of test for both sexes is about the same at age 10, as age advances the ability to correctly solve the B type problem falls far below the type A solving ability. This difference is still greater than the figures indicate when one remembers that all the former problems were of a grade within the reach of the tested pupils, whereas three of the problems of Test A were mechanically beyond their range of ability. This seems to be a significant feature. Thirdly, it is to be observed that the younger boys obtain a considerably higher score in both types of questions than the younger girls, but the superiority is lost with increase in age, since the girls of 13 years of age excel by a significant figure.

CHAPTER IV

ANALYSIS OF DATA

Variables.--The direct variables involved in this investigation are sex, age, I. Q., Test A score and Test B score. In addition to these, it should be remembered in an attempt to interpret the results obtained, that a number of indirect factors undoubtedly enter. These are the various factors which might be grouped in the term environmental influence and experience. These indirect variables are, unfortunately, uncontrollable in a work of this nature, and would in all probability be responsible for some of the irregularities which are found in parts of our analysis. For example, we find in Grade V. a girl of 13 years of age with an I. Q. of 125. This is not a normal case, but it has been impossible to deal with such cases individually, partly owing to the large amount of assistance which would be required from teachers or principals, some of whom might feel that an unnecessary burden was being placed upon them in obtaining all the desired information. On the other hand, Tests A and B deal solely with Arithmetic, and only experience in this field will have a direct influence upon the results recorded. This experience, it is safe to say, is gathered to a very large degree in the school room and hence tends to offset outside influences. At these immature ages, the pupils have not sensed many of even the simpler mathematical problems of life. This is probably more true of the girls. But where such outside experience does influence the results obtained it should be recognized in our classrooms.

TABLE V

SUMMARY OF AVERAGE SCORES OBTAINED ON TESTS A AND B

CLASSIFIED ACCORDING TO SEX, AGE AND I. Q.

I. Q.	Under 95		95 - 105		Above 105	
Age	A	B	A	B	A	B
9					3.33	4.00 (3)
					3.50	3.10 (10)
10			3.87	3.47 (15)	<u>4.41</u>	<u>4.44</u> (34)
			3.17	2.83 (24)	<u>3.98</u>	3.78 (54)
11	3.08	2.46 (13)	3.98	3.57 (46)	5.04	4.60 (25)
	3.43	3.21 (14)	3.76	3.48 (33)	4.20	4.13 (30)
12	3.52	3.26 (27)	3.85	5.00 (13)	3.67	3.33 (3)
	3.36	2.75 (28)	3.63	4.75 (8)	3.50	3.00 (2)
13	3.82	2.76 (17)	4.50	5.50 (2)	----	---- (0)
	4.14	3.57 (7)	3.50	2.50 (2)	7	10 (1)
14	4.44	3.89 (9)				
	----	---- (0)				

The underlined items in Table V. are read as follows: 4.41 is the average score on Test A for boys 10 years of age with an I. Q. of more than 105. 4.44 is the average score on Test B. for the same group. There were 34 boys in the group. 3.98 is the average Test A score for the parallel group of girls.

Influence of Age and I. Q. on Problem Solving Ability.- Table V. presents a summary of scores, grouped according to age and I. Q. A study of the figures brings to light the following information:

(1) Test A solving ability increases as age increases for both boys and girls.

(2) Test B solving ability increases as age increases in both boys and girls.

(3) For any age, the ability to solve either type of problem increases rapidly as the I. Q. of the pupil increases.

(4) I. Q. is a more influential factor than chronological age in determining ability.

(5) A marked increase of ability is apparent at the following points:-

(a) Less than 95 I. Q. at 14 years of age.

(b) 95 to 105 I. Q. at 12 years of age.

(c) Higher than 105 I. Q. at 10 years of age.

The average mental age of each of the groups referred to in (5) above was computed and found to be as follows:

	I. Q.	C. A.	Ave. M. A.
Boys	Below 95	14 yrs.	10 yrs. 7 mos.
	95 - 105	12 yrs.	11 " 9 "
	Above 105	10 yrs.	11 " 8 "
Girls	Below 95		
	95 - 105	12 yrs.	11 yrs. 9 mos.
	Above 105	10 yrs.	11 " 9 "

Unfortunately, the number of girls of 14 years of age of low I. Q. was insufficient for purposes of comparison.

With the exception of the oldest group of boys, whose previous attempts were doubtless a contributing factor, all other groups had an average mental age of close to twelve years. Here we have a point at which mental development has reached a stage of actual understanding. In other words, before a pupil has reached the mental age of 11 years 8 months, problem solving ability is rather an ability to arrive at the correct answers by mechanically (not understandingly) following the various steps taught by the teacher. One of the most difficult tasks confronting the Grade V. teacher of Arithmetic is teaching the pupils of an average class how correctly to solve problems. When one has had experience with students of higher grades, this difficulty of the Grade V. teacher can be appreciated. This information obtained above, appears of particular significance and will be referred to later.

A more detailed analysis of scores on basis of sex, age, and I. Q. is given in Tables VI. and VII.

TABLE VI[1]

DISTRIBUTION OF BOYS' A AND B SCORES ACCORDING TO AGE AND I. Q.

I. Q.	Age in years. 9		10		11		12		13		14	
- 89					2.4	2.6	3.5	3.1	3.9	2.9	4.4	3.9
90 - 96			5.0	3.0	3.8	2.9	3.6	4.0	4.7	5.0		
97 -103			4.1	3.1	3.9	3.6	3.9	4.8				
104-110			4.1	4.5	4.9	3.8	3.7	4.7	3.0	4.0(1)		
111-117	2.0	3.0	4.3	4.5	5.0	5.4						
118-	6.0(1)	6.0	4.7	4.7	5.1	5.1						
											16 yr.	
											(69)7.0	5.0

TABLE VII

DISTRIBUTION OF GIRLS' A AND B SCORES ACCORDING TO AGE AND I. Q.

I. Q.	Age in years											
- 89					3.3	3.3	3.2	2.8	4.8	4.3	4.3	2.3
90 - 96			4.0	2.5	3.5	2.9	3.6	3.0	5.0	4.3		
97 -103			3.1	3.1	3.7	3.9	3.5	5.0	3.5	2.5		
104-110			3.3	3.2	3.9	2.6	3.8	4.0				
111-117	2.8	3.2	4.1	3.6	4.6	4.7			7.0	10.0(1)		
118-	4.2	3.0	4.5	4.5	4.4	5.9						

[1] For interpretation of Tables VI. and VII. see Footnote under Table V.

Table VIII. gives a comparison of the average of all A and B scores for each sex on the basis of I. Q. rating regardless of age. These results are represented graphically in Figure I.

The following may be read from the graph:-

(1) Generally speaking, the boys have slightly higher scores than the girls, in both types of problems.

(2) A marked increase of problem solving ability with increase in I. Q. is evident for both sexes.

(3) Test B solving ability is superior to Test A solving ability in case of the higher I. Q.'s but not in case of the lower I. Q.'s.

TABLE VIII

AVERAGE A AND B SCORES FOR EACH SEX BY I. Q.

I. Q.	-89		90-96		96-103		104-110		111-117		118-	
Boys	3.6	3.0	3.9	3.5	3.8	3.6	4.3	4.1	4.1	4.6	4.7	4.8
Girls	3.7	3.4	3.6	3.0	3.4	3.7	3.7	3.3	4.0	3.9	4.1	4.3

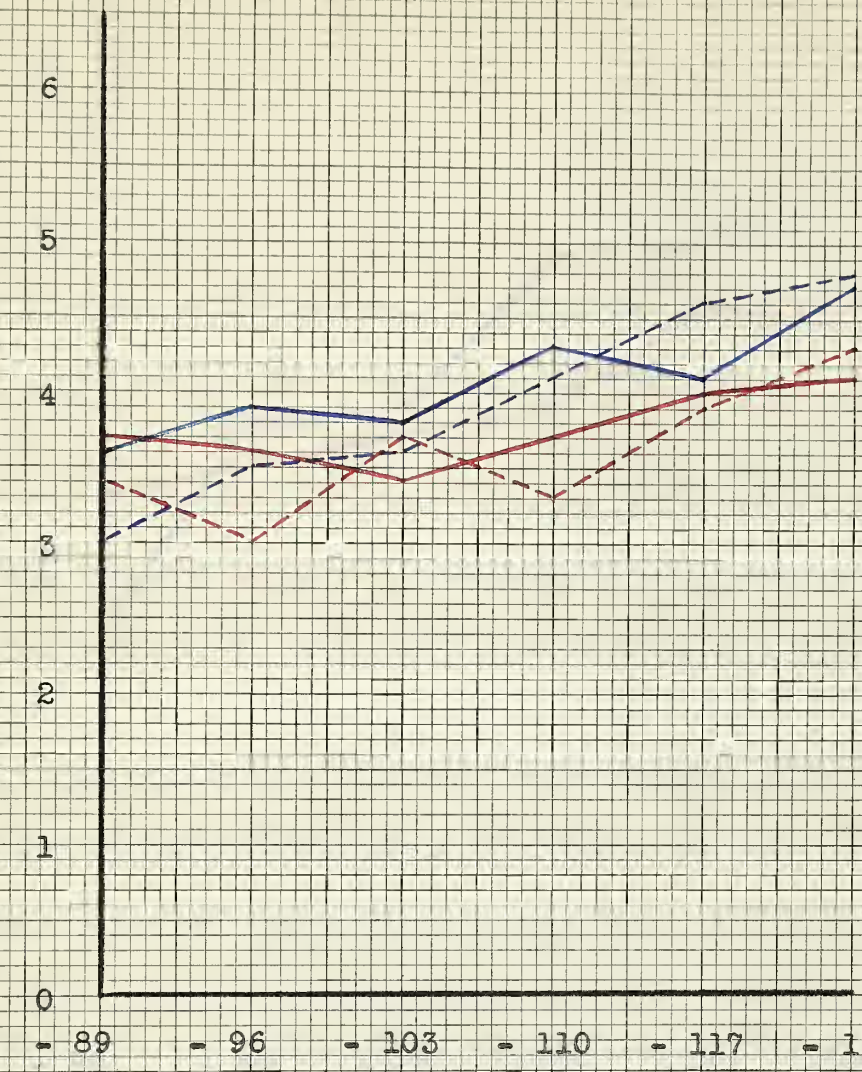
Figure 2 presents graphically the comparison of Test A scores of boys and girls, of different I. Q.'s but of constant age of 11 years; while Figure 3 presents a corresponding Test B score curve. Figures 4 and 5 show Test A scores against I. Q. for constant ages; while figures 6 and 7 are corresponding Test B score curves. The numbers of pupils for both extremes of ages and extremes of I. Q.'s were relatively small. This

fact may help to account for the irregularities at these points. Despite the apparent fluctuations, certain tendencies are apparent:-

(1) Increase in score accompanies increase in I. Q. for the same age.

(2) For a given I. Q., older pupils obtain higher scores than younger pupils.

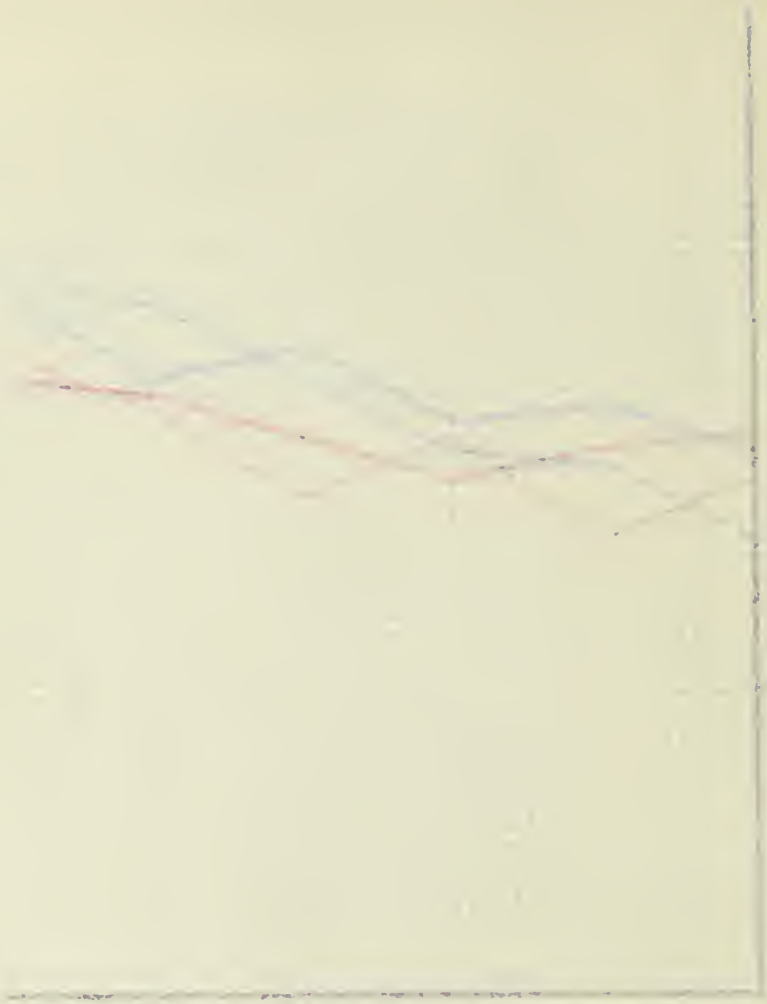
(3) Boys' scores are relatively higher than girls' scores.



Boys ——— blue
Girls——— red
Test A———
Test B- - - -

Fig. 1. Distribution of A and B scores on basis of sex and I. Q.

Note. Throughout this report boys' scores will be shown graphically in blue, girls' scores in red.



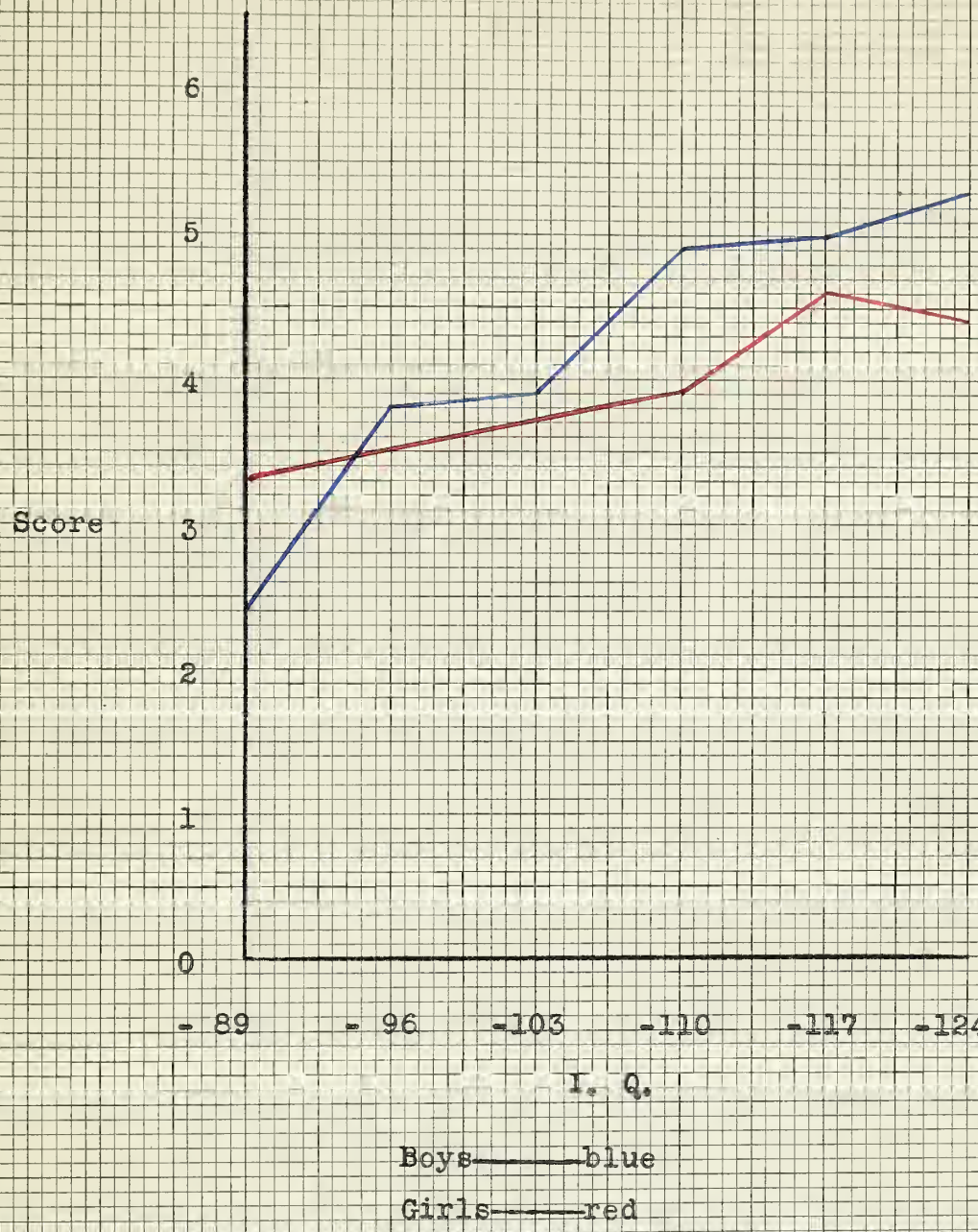


Fig. 2.- Distribution of Test A scores for age 11.

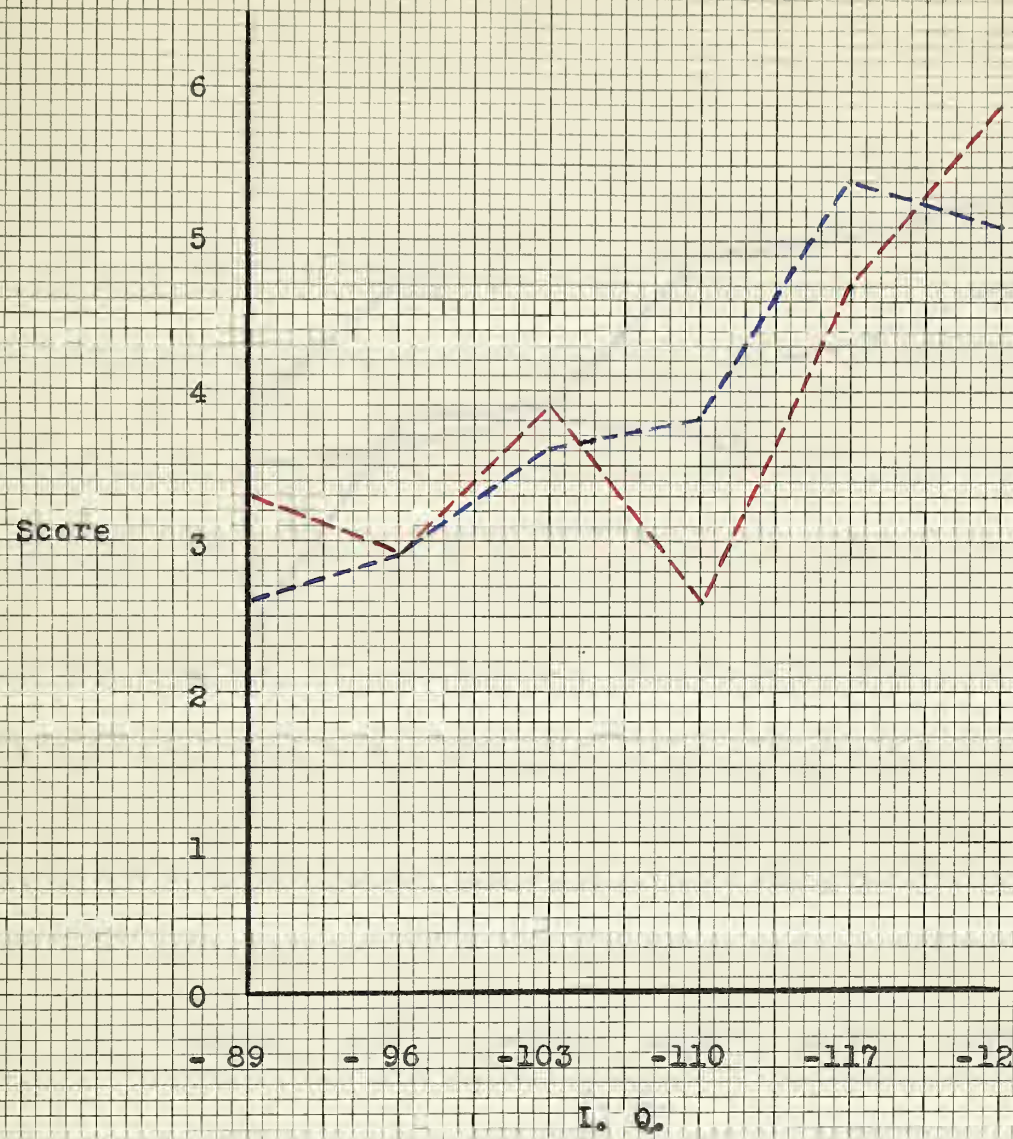
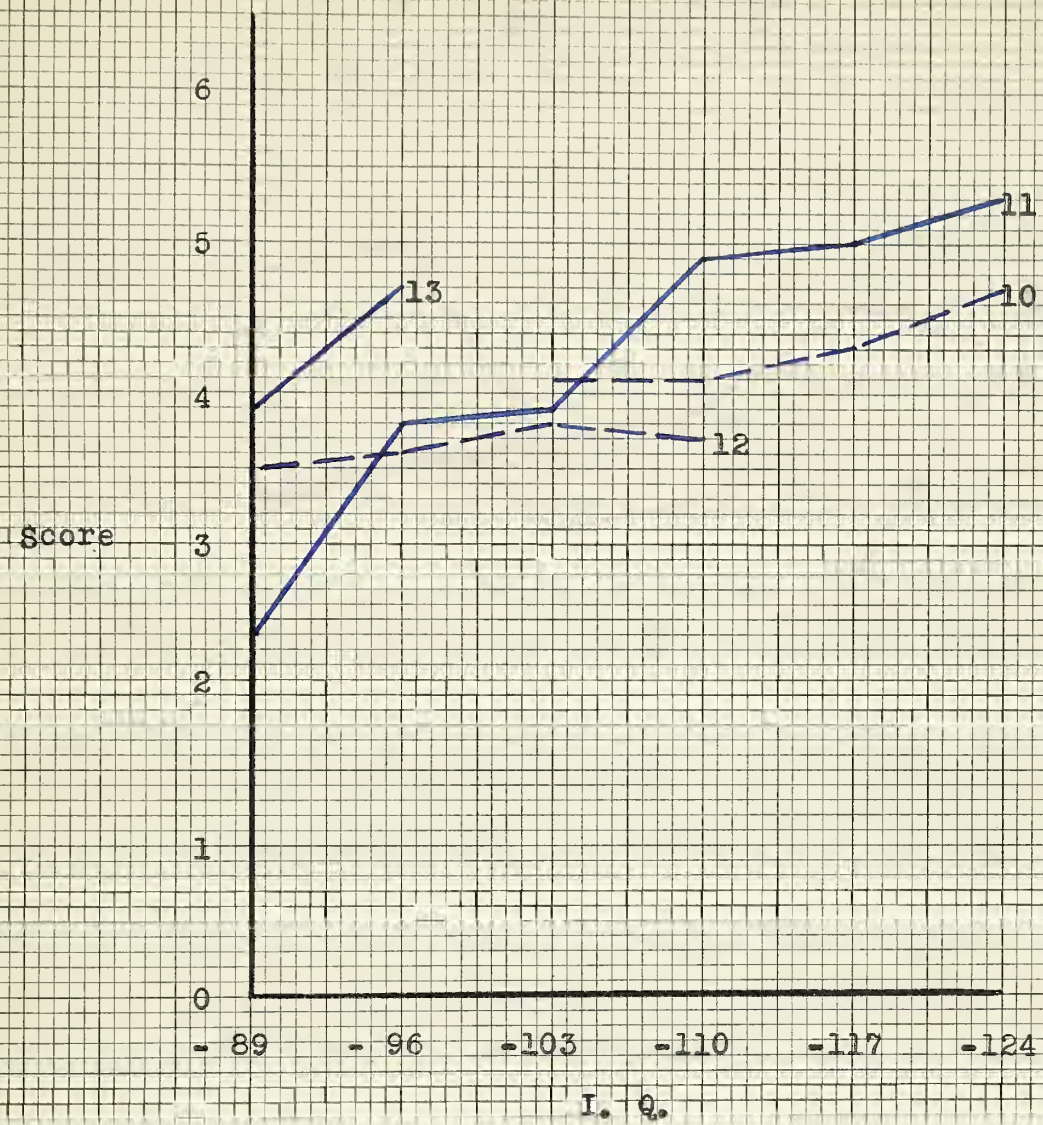
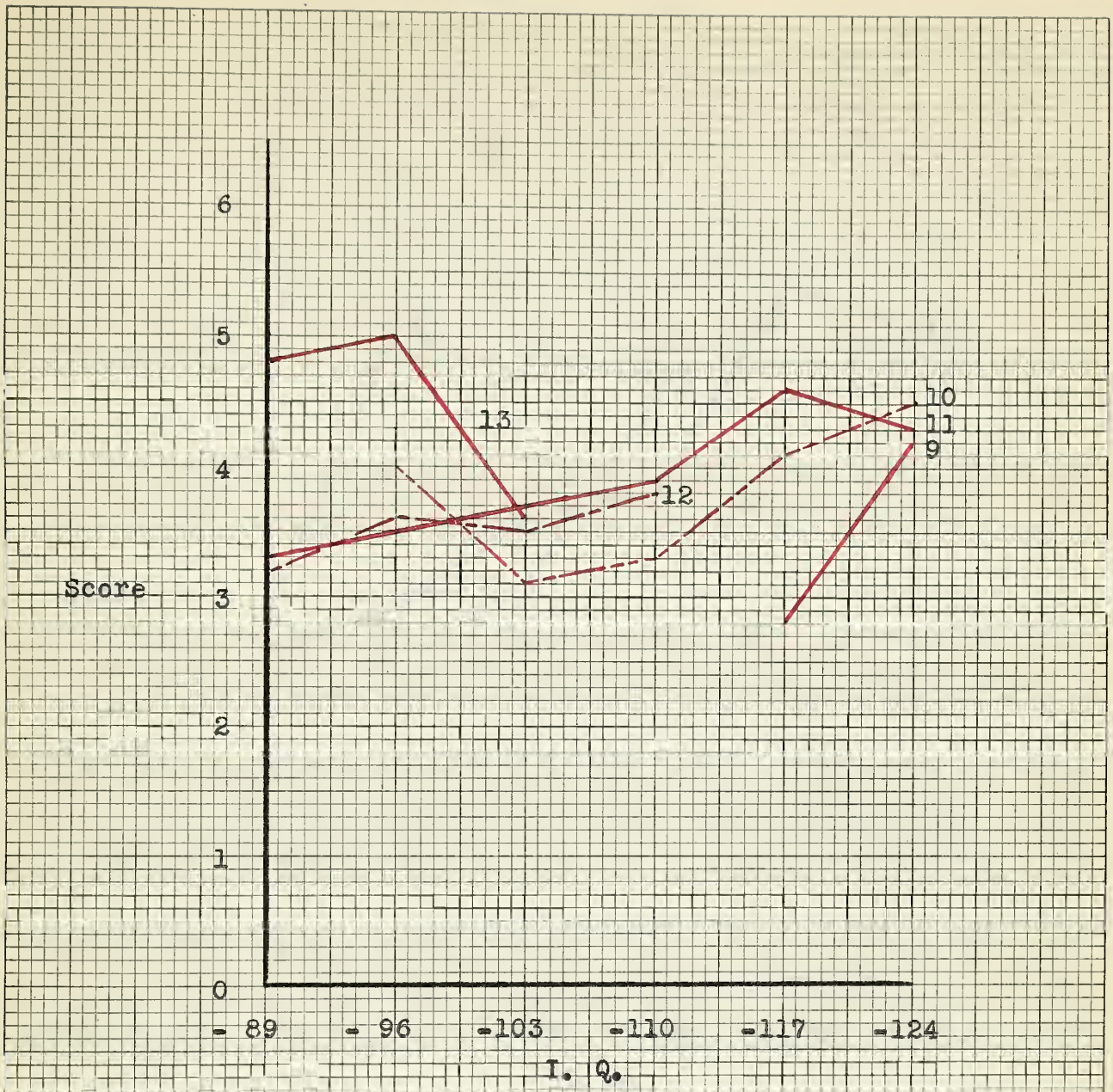


Fig. 3. - Distribution of Test B scores at age 11.



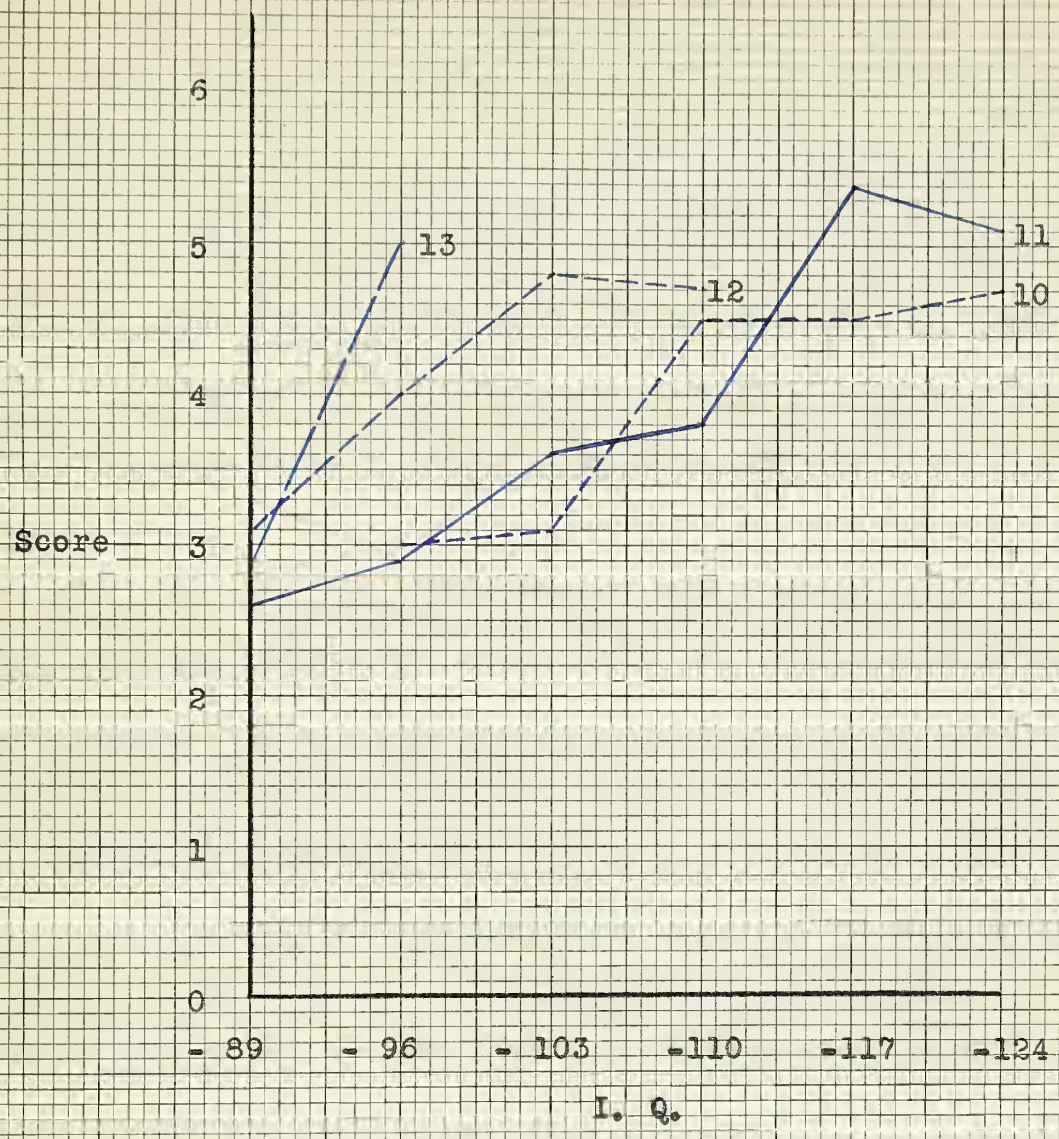
Age indicated at right of curve.

Fig. 4. - Distribution of boys' Test A scores for ages 10 to 13.



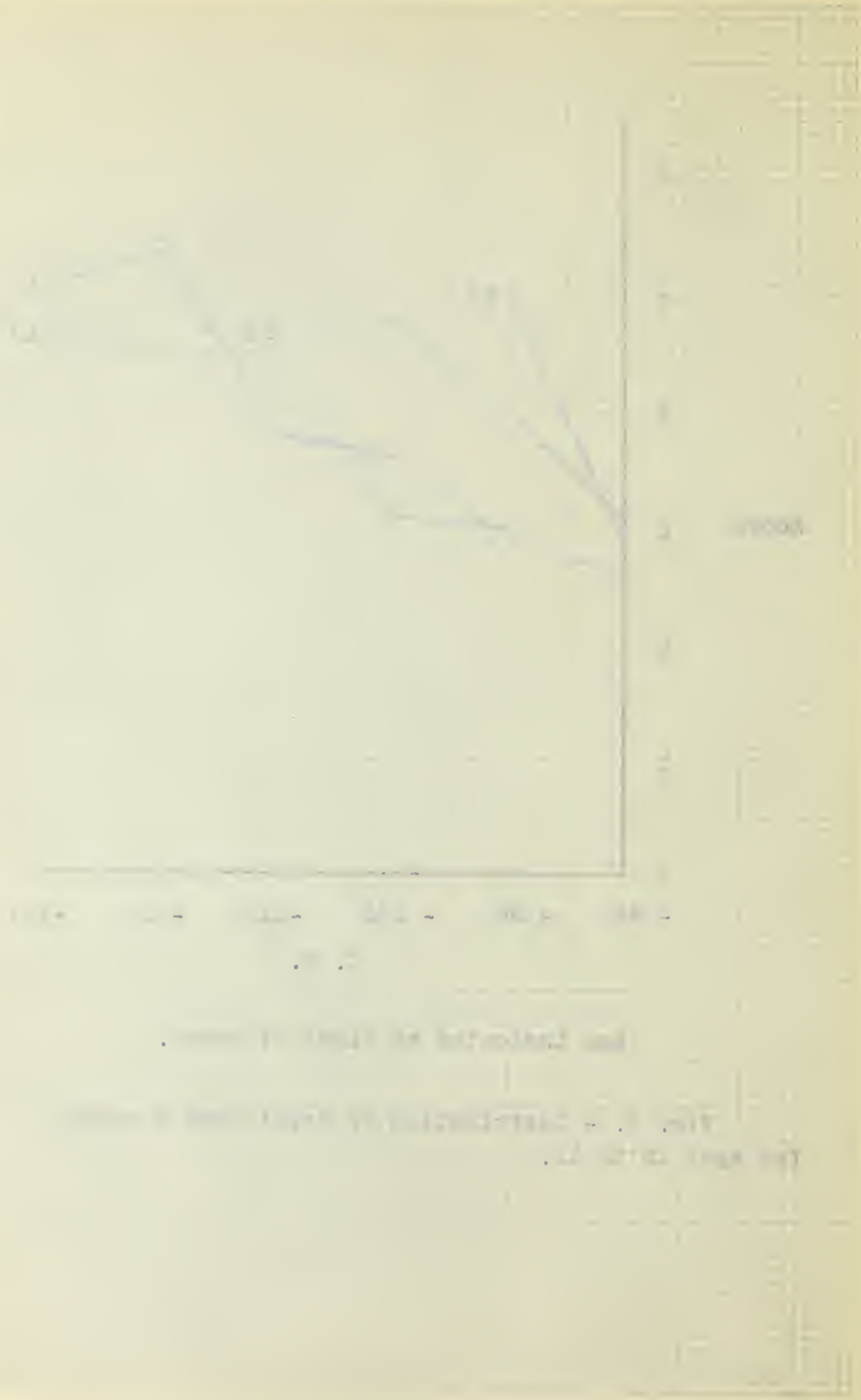
Age indicated at right of curve.

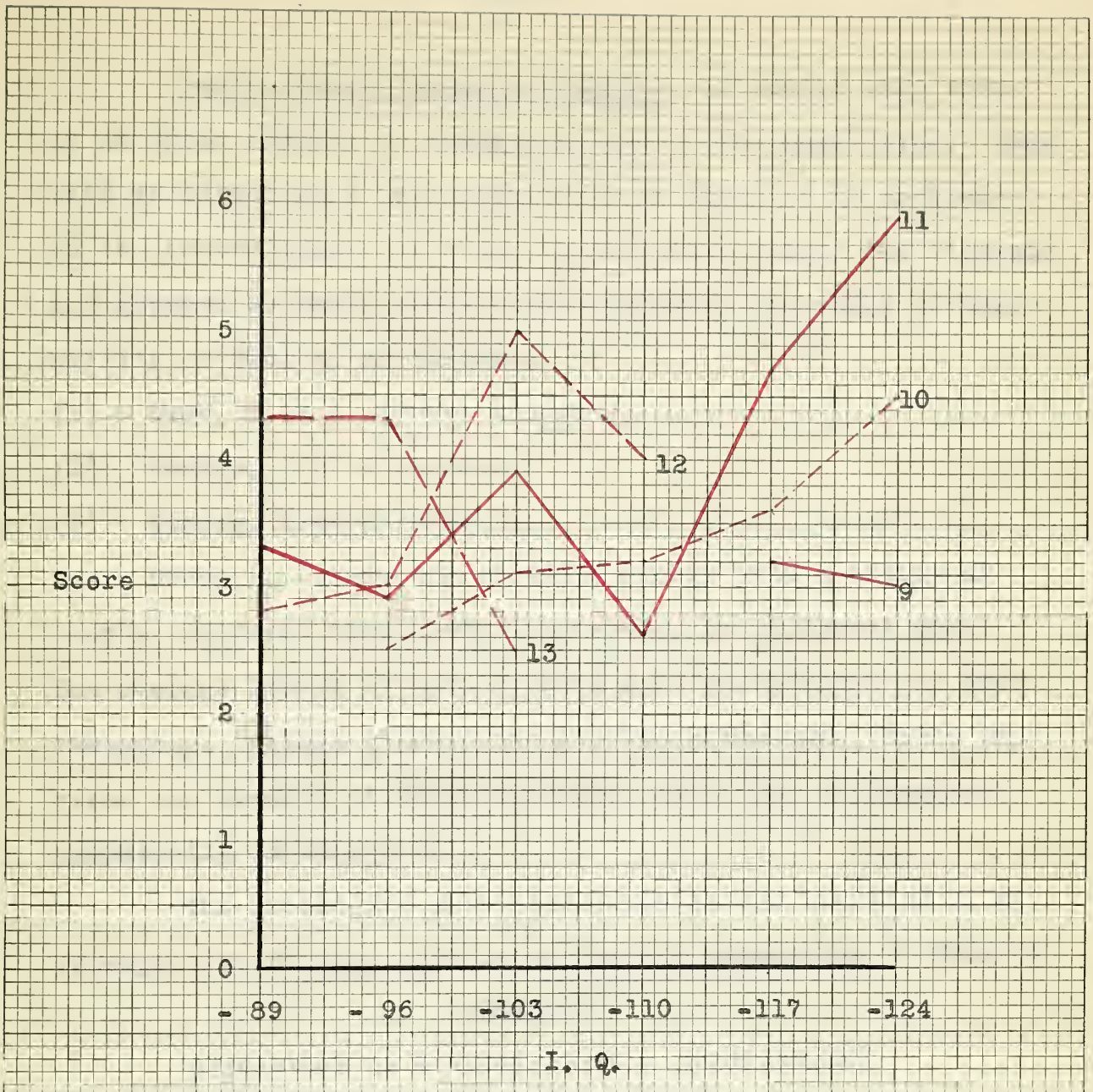
Fig. 5. - Distribution of girls' Test A scores for ages 9 to 13.



Age indicated at right of curve.

Fig. 8. - Distribution of boys' Test B scores for ages 10 to 13.





Age indicated at right of curve.

Fig. 7. - Distribution of girls' Test B scores for ages 9 to 13.

Test A Scores Grouped by Pairs.--Students vary widely in their ability to solve problems of the usual type. Does this variation hold true relatively in the case of problems of the second type? In order to test this point, the students are grouped by sexes, into three divisions according to their ability on Test A, as follows:

(1) Weak, 1 or 2 correct A scores;

(2) Medium, 3 or 4 correct;

(3) Strong, 5 or 6 correct.

Group 1, consisting of those pupils with A scores of 1 or 2, is first subdivided into groups of different ages. The average scores of both A and B are now obtained for each sub-group. Groups 2 and 3 are similarly treated. Table IX. gives the summary of these averages, which are represented graphically in Figure 8.

The groups are next subdivided on the basis of I. Q., irrespective of age, and the scores are summarized in Table X.

TABLE IX

COMPARISON OF B SCORES WITH A GROUP-SCORES

ON THE BASIS OF AGE

	Boys											
	Age											
Group	9		10		11		12		13		14	
	A	B	A	B	A	B	A	B	A	B	A	B
1 & 2	2.0	3.0	2.0	2.8	1.9	2.8	1.9	2.3	1.8	.8		
3 & 4			3.4	3.1	3.5	3.5	3.6	3.8	3.4	3.0	3.5	4.0
5 & 6	6.0	6.0	5.4	5.3	5.3	4.2	5.5	5.5	5.5	4.8	5.5	3.5

TABLE IX[1] (continued)

Girls

Group	Age 9		10		11		12		13		14
	A	B	A	B	A	B	A	B	A	B	
1 & 2	1.5	2.0	1.7	2.0	1.7	2.9	1.8	1.7	2.0	0. (1)	
3 & 4	3.6	3.3	3.5	3.2	3.5	3.4	3.5	3.5	4.0	4.5	
5 & 6	5.0	3.0(2)	5.3	5.3	5.1	4.5	5.4	4.2	5.2	4.3	

TABLE X[2]

COMPARISON OF B SCORES WITH A GROUP-SCORES

ON THE BASIS OF I. Q.

Boys

Group	I. Q. -89		90-96		97-103		104-110		111-117		118-	
	A	B	A	B	A	B	A	B	A	B	A	B
1 & 2	1.8	1.5	2.0	2.8	2.0	2.8	2.0	4.0(2)	2.0	2.8		
3 & 4	3.5	3.2	3.5	3.3	3.5	3.5	3.5	3.5	3.8	4.1	3.7	4.0
5 & 6	5.5	4.2	5.4	4.3	5.4	4.4	5.5	4.7	5.1	5.6	5.5	5.5
					Girls							
1 & 2	1.7	2.2	2.0	1.6	1.6	1.9	1.8	2.4	1.7	2.3	1.7	3.0
3 & 4	3.5	3.2	3.5	2.9	3.4	4.0	3.6	3.0	3.6	3.5	3.6	4.0
5 & 6	5.6	3.4	5.2	4.2	5.1	4.5	5.1	4.5	5.5	5.2	5.4	5.3

[1]The underlined items "3.6" and "3.8" in Table IX. are interpreted thus: The average Test A score for all 12 year old boys who correctly solved either 3 or 4 Test A problems was 3.6. The average Test B score for the same group was 3.8.

[2]In Table X, the underlined items "5.6" and "3.4" are interpreted thus: The average Test A score for all the girls of less than 90 I. Q., who correctly solved either 5 or 6 Test A problems was 5.6. This same group of girls solved correctly an average of only 3.4 problems on Test B.

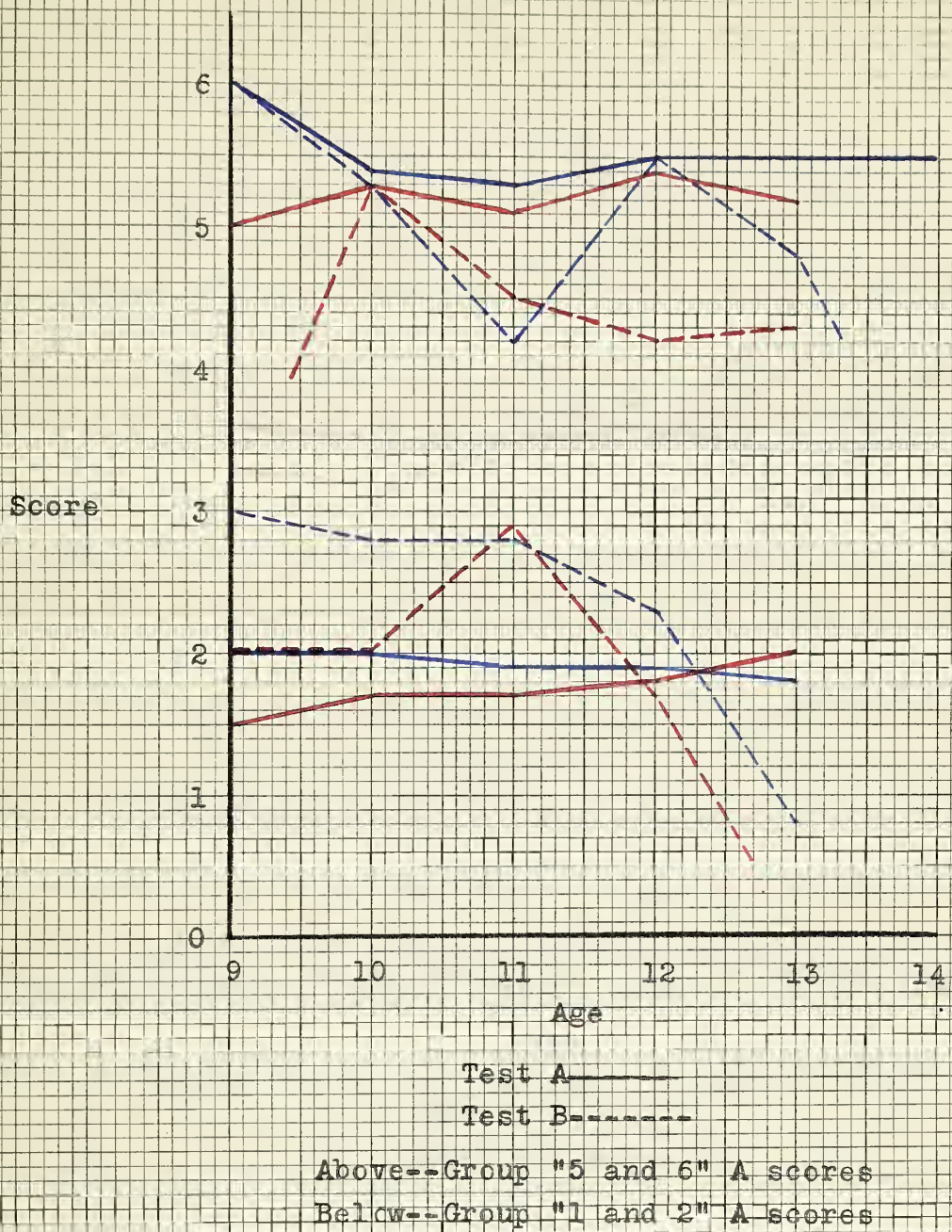


Fig. 8a. - Comparison of Test B scores with Test A group-scores, on basis of age.

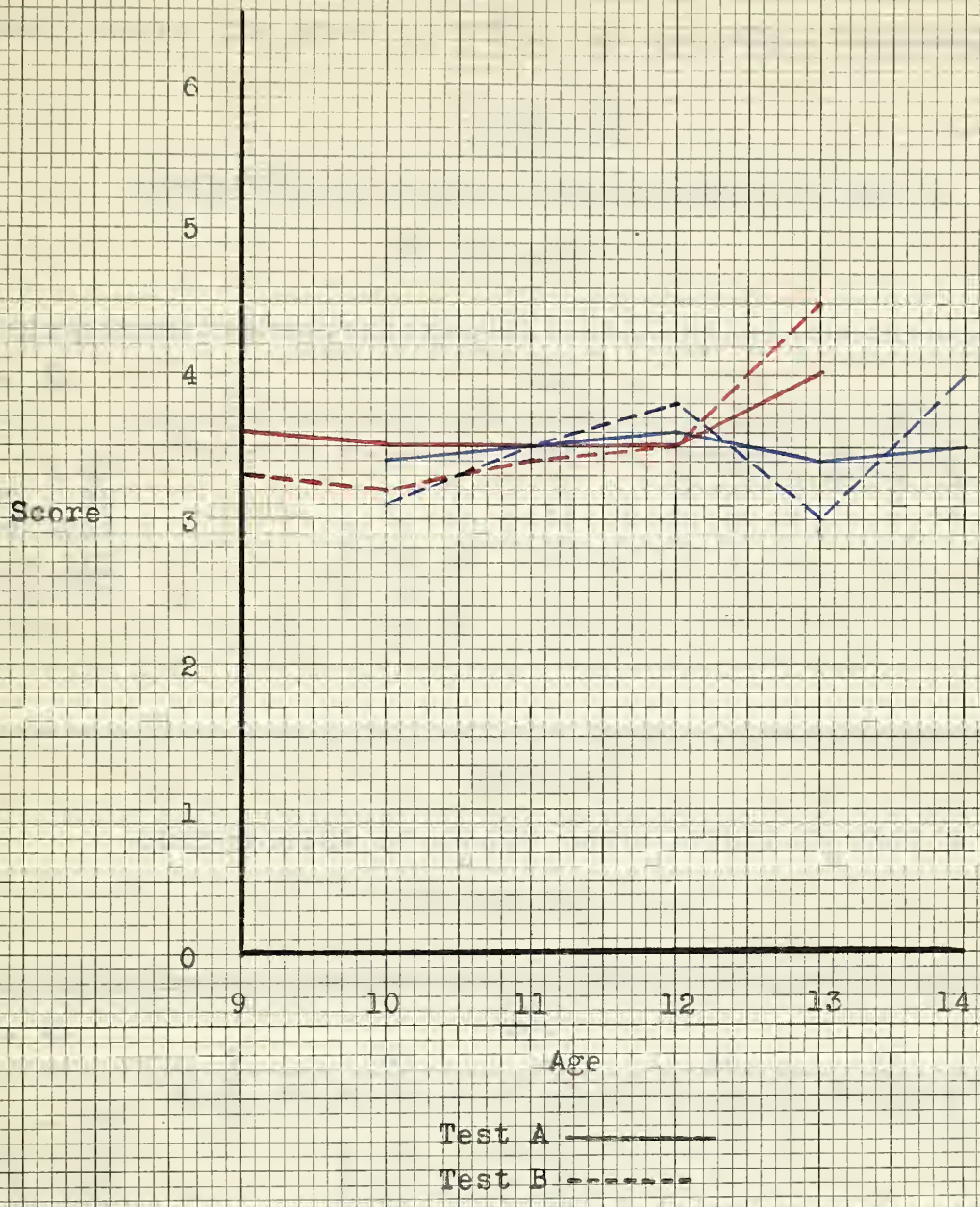


Fig. 8b. - Comparison of Test B scores with Test A group-scores on basis of age.

The numbers of boys and girls represented in each group-score are given in Tables XI. and XII., respectively.

TABLE XI[1]

DISTRIBUTION OF BOYS' GROUP-SCORES ON TEST A

BY AGE AND I. Q.

I. Q.	Age																	
	9			10			11			12			13			14		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
- 89							3	2		5	7	4	4	8	4		4	4
90 - 96						1	1	11	4	3	9	2		1	2			
97 -103				2	7	5	4	21	7	2	3	4						
104-110				1	9	4		4	10	1	1	1		1				
111-117	2			1	6	6		2	4		1							
118-			1		4	4		3	3									

TABLE XII

DISTRIBUTION OF GIRLS' GROUP-SCORES ON TEST A

BY AGE AND I. Q.

I. Q.	Age																	
	9			10			11			12			13			14		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
- 89		1						1	1	6	8	3		2	2			
90 - 96				1	2		3	13	2	3	6	4			3			
79 -103				4	6	2	4	11	6		4		1		1			
104-110				7	18	4	1	12	4		3							
111-117	2	3			14	4	1	4	5									
118-		3	2	2	5	7	1	3	1									

15 yr.
1 (c)

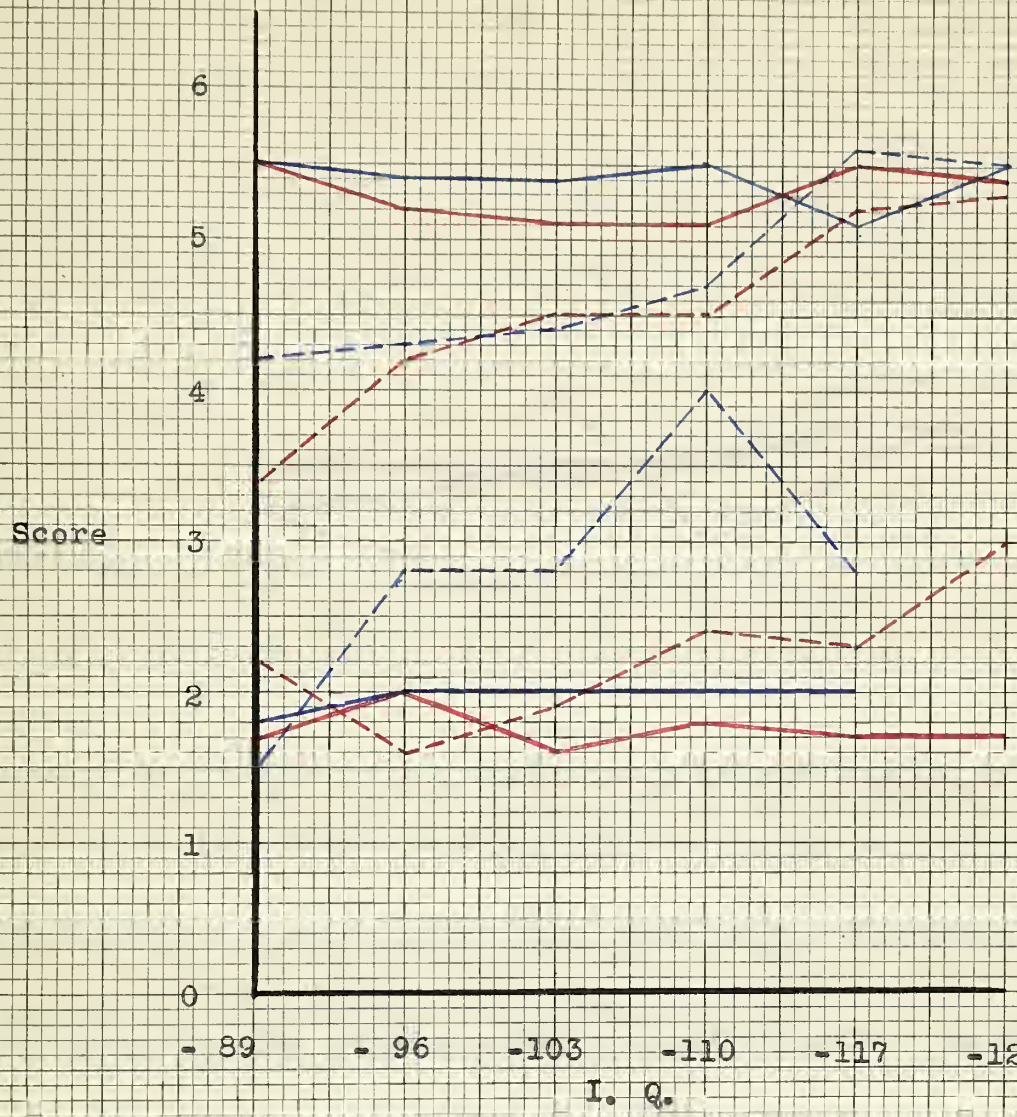
[1]The underlined figures in Table XI. are read as follows;
"5" - 5 boys, 12 years of age, and with an I. Q. under 90, obtained scores of either 0, 1, or 2 on Test A.
"3" - 3 boys, 12 years of age, and with an I. Q. between 90 and 96 obtained scores of either 0, 1 or 2 on Test A.
"7" - 7 boys of age 12, with I. Q. less than 90, obtained scores of either 3 or 4 on Test A.

The results given in Tables IX. and X. are shown graphically in Figures 9 and 10.

Interpretation of Figures 9 and 10.--The curves representing Test A scores are approximately horizontal since they represent scores lying within two narrow limits. The B score curves show wide variations of ability. Examining first of all Figure 9, (Test A scores, "1 and 2"), we find the pupils of low mental ability receive approximately the same score on each of tests A and B; while the brighter students show marked increase of ability in dealing with Test B questions. In Figure 10, representing those pupils who obtained scores of 3 or 4 correct on Test A., the weaker pupils once again show a lesser degree of ability in dealing with the Test B type, while here the brighter ones again excel.

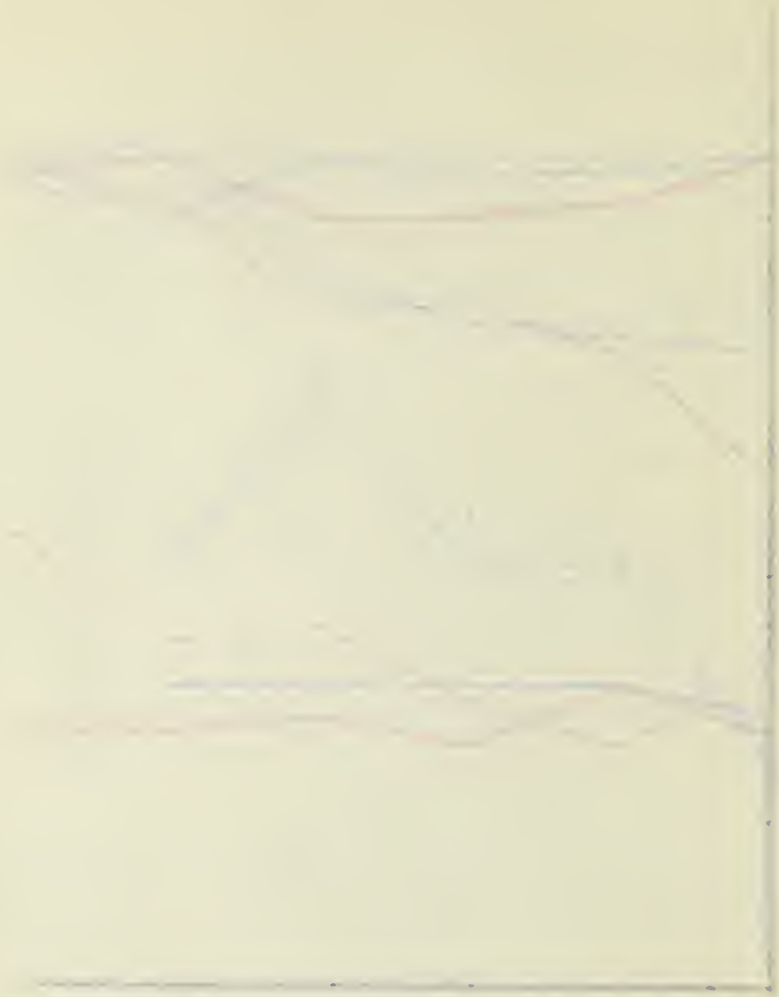
In the " 5 and 6" group a marked decline in Test A solving ability is evident among the duller pupils, while the brighter ones exhibit equal ability in the two tests. These conclusions hold for each sex, with the boys rating somewhat higher in the majority of cases. When grouped on this basis, age does not appear to be such an influential factor as I. Q. (See Fig. 8)

Table XI. shows the distribution by age and I. Q. of the boys' Test A group-scores (grouped as above), while Table XII. gives the girls' group-score distribution. These tables make it clear, as would be suspected, that the older pupils show far less ability than their younger classmates, being of a lower I. Q.



Above--Group "5 and 6" A scores
Below--Group "1 and 2" A scores
A scores———
B scores- - - - - -

Fig. 9. - Comparison of Test B scores with Test A group-scores, on basis of I. Q.



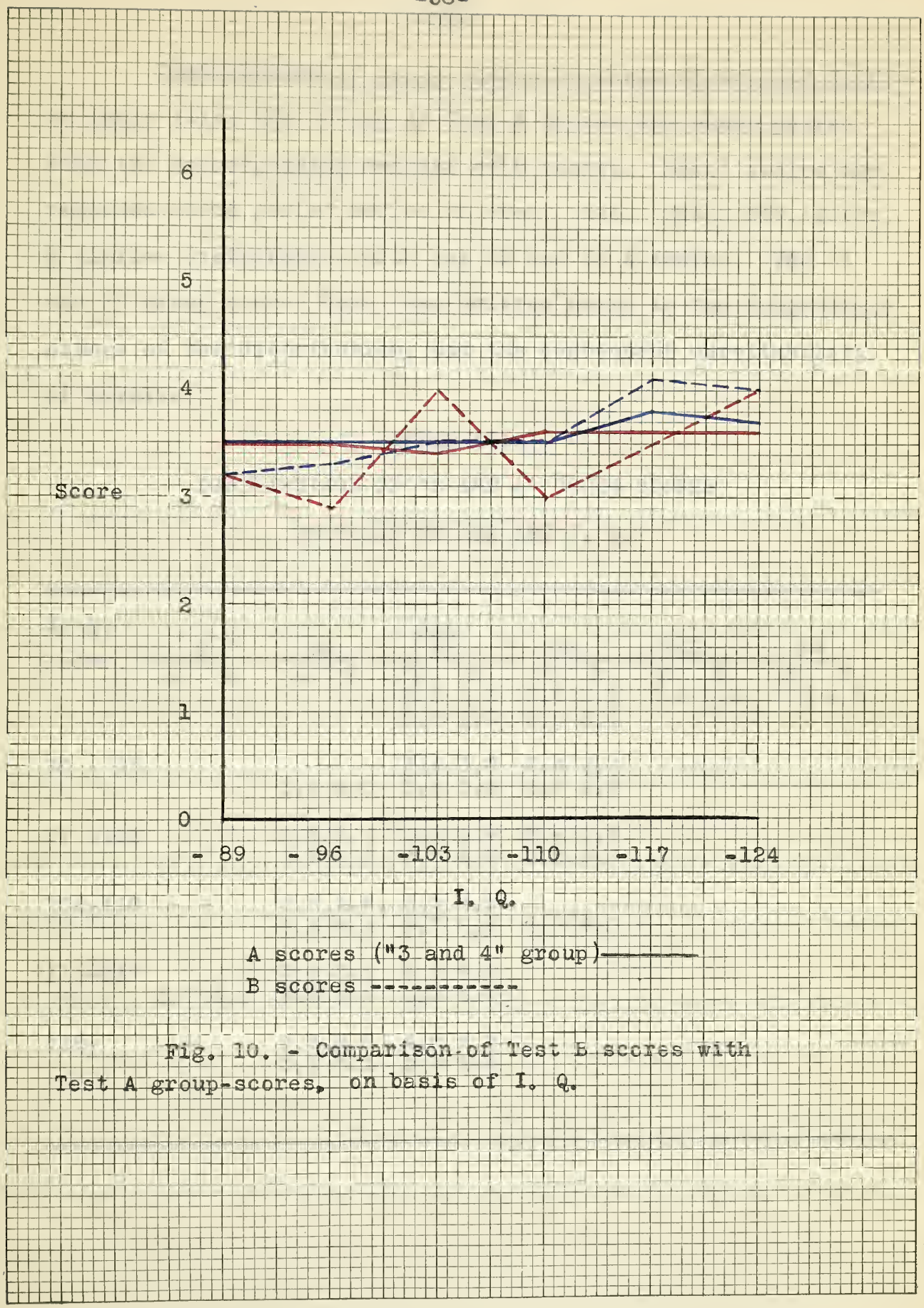


Fig. 10. - Comparison of Test B scores with Test A group-scores, on basis of I. Q.

Distribution of group-scores on basis of age and I. Q.--

In Table XIII. the "3 and 4" Test A scores are shown paired with the corresponding average of B scores. Boys' scores are recorded above girls' scores in every case. Table XIV. gives a similar distribution with the "5 and 6" A scores. The "1 and 2" group scores have been omitted owing to the fragmentary nature of the distribution, and the consequent unreliability of results.

TABLE XIII

DISTRIBUTION OF "3 AND 4" GROUP-SCORES

ON BASIS OF AGE AND I. Q.

I. Q.	Age 9		10		11		12		13		14	
	A	B	A	B	A	B	A	B	A	B	A	B
- 89					3.5	3.0	3.6	3.1	3.5	3.0	3.5	4.0
					3.0	3.0	3.5	3.1				
90 - 96					3.4	3.0	3.4	3.4				
			3.5	2.0	3.5	3.2	3.3	2.7				
97 -103			3.6	2.4	3.4	3.4	3.4	5.7				
			3.3	3.2	3.5	4.2	3.5	5.0				
104-110			3.6	3.6	3.5	2.8						
			3.5	3.3	3.7	2.2	3.7	4.0				
111-117			3.8	3.8	4.0	6.5						
	3.7	4.0	3.6	3.2	3.8	4.5						
118-			3.8	4.0	4.0	4.5						
			3.7	3.3	3.3	5.3						

TABLE XIV

DISTRIBUTION OF "5 AND 6" GROUP-SCORES

ON BASIS OF AGE AND I. Q.

I. Q.	Age 10		11		12		13		14	
	A	B	A	B	A	B	A	B	A	B
- 89					5.5	4.8	5.8	4.5	5.5	3.5
			5.0	4.0	5.7	3.3	5.5	4.0		
90 - 96	5.0	3.0	5.5	2.5	5.5	7.0	5.5	6.0		
			5.5	3.0	5.2	4.8	5.0	4.3		
97 -103	5.6	4.4	5.7	4.3	5.3	5.0				
	5.0	6.0	5.2	4.0			5.0	5.0		
104-110	5.8	6.0	5.4	4.4	6.0	6.0				
	5.0	4.5	5.3	4.5						
111-117	5.2	5.7	5.4	5.0						
	5.3	5.3	5.8	5.2						
118-	5.7	5.8	6.0	5.5						
	5.6	5.6	5.0	8.0(1)						

It must be borne in mind that the extremities represent in many cases the averages of a small number of scores, or even individual scores. An examination of the figures in the above (or preceding) tables then reveals the following facts:

(1) The higher the I. Q. for any age, the higher is the B score.

(2) To a less marked degree, increase in age results in increase in B score.

(3) The boys' B scores exceed the girls' B scores in 16 cases out of the 25 in which both scores occur. This tendency was more marked in the case of the "1 and 2"A score com-

parison referred to above. In this case, the boys' scores excelled in 5 cases out of 6.

Deviations and Correlations.--The standard deviations, calculated on the basis of sex and age, gave the results shown in Table XV.

TABLE XV

DEVIATIONS AND CORRELATIONS OF SCORES

BY SEX AND AGE

Sex	Age	No.	σ_A	σ_B	r_{AB}
Boys	10	85	1.25 ± .06	1.98 ± .10	.54 ± .05
	11	49	1.37 ± .09	1.98 ± .13	.39 ± .08
	12	43	1.95 ± .14	2.32 ± .17	.78 ± .04
Girls	10	78	1.38 ± .07	1.82 ± .09	.50 ± .06
	11	77	1.38 ± .07	2.02 ± .10	.36 ± .07
	12	38	1.27 ± .09	1.80 ± .14	.51 ± .08

The deviations for the B scores are seen to be greater than for the A scores. This is, doubtless, a result of the familiarity of the pupils for the A type, while the B type problem was something out of the routine of daily drill.

The following extract from the table, showing the correlation between the A and B scores, is interesting:

Age	10	11	12
Boys	.54	.39	.78
Girls	.50	.36	.51

The eleven year old pupils of both sexes show a low correlation, although the number of pupils is satisfactory.

The correlations of these same pupils is found to be consistently low for different I. Q.'s, while the 10 year old students remain around .5. The 13 year old students of both sexes have high correlations. The highest correlations are found in the scores of the older pupils, doubtless due to the fact that the number of correct solutions is considerably smaller with this group.

This marked low correlation with the students of normal Grade V. age, may be one of those irregularities often encountered in the examination of data. It may be due to an unfortunate sampling of 11 year old pupils, but this seems hardly probable, particularly as this is evident with the scores of both sexes. The writer has found it difficult to explain this seeming discrepancy, but suggests the following as a plausible explanation. The younger students, as a group, are of a higher order of mental ability than the remainder, and they profit by this, with relatively high scores in both tests. The older pupils, generally retarded, fail to obtain a high average score in either test, and are therefore found to be successful in a few of the easier problems of each test. The students of normal age make medium scores in both, but the B scores are more widely distributed over the 10 problems in this group of students, thereby lowering the correlation.

CHAPTER V

CONCLUSIONS

Having summarized the data in the previous chapter, we are now in a position to interpret these figures collectively and to determine the relation, if any, existing between problem solving ability and each of the variables under consideration.

Relation between Problem Solving Ability and Sex

A study of Table II. reveals that the total numbers of correct solutions obtained on the two tests is as follows:

	Test A	Test B
Boys	857	692
Girls	836	677

It appears from this that the boys have been more successful than the girls. Two facts, must, however, be kept in mind; (1) The number of girls exceeds the number of boys; (2) the average age of the girls is approximately .41 years less than that of the boys. It is necessary, therefore, to select representative groups for purposes of comparison.

In Table IV. we have seen that the boys obtained a higher average score than the girls in both tests, at ages 10, 11 and 12. The 13 year old boys are less successful than the girls of the same age. This evidence is further borne out in Table V. where the boys of a given age and I. Q. have been more successful in Test A. in 8 cases out of 11 where comparisons are possible, and in Test B in 9 of the 11 cases compared. Of the total 5 cases in which the girls' scores are the higher, 4 occur in the lowest I. Q. group. This substantiates the

conclusion arrived at in Table IV., where the oldest girls (i.e. those of lowest I. Q.) obtained higher scores than the boys. The slightly greater success of the boys is still further shown in Table VIII., where on the basis of I. Q. alone, their scores are exceeded by those of the girls in only 3 cases out of 12.

In Figure I, which represents graphically a comparison of boys' and girls' scores, the superior ability of the boys is verified in each test.

Since the 11 year group contains the largest number of pupils, and as these are, generally speaking, the pupils of average ability, a comparison of the two sexes at this age should be of considerable value. Figures 2 and 3, obtained from data in Tables VI, and VII., compare the scores of the successive mental levels at 11 years of age. The findings referred to earlier are once more confirmed.

The 10 year old group and the 12 year old, which are the next largest groups, show the boys again to be in the lead, whereas the 13 year old girls excel. (See Figures 4 to 7). These conclusions are applicable to both sets of scores.

The following summary, obtained from the figures of Tables XIII. and XIV., show the number of times the boys' average score exceeded that of the girls', and vice versa.

A group score.	1 - 2		3 - 4		5 - 6	
Test	A	B	A	B	A	B
Boys	4	5	9[1]	8	9	8
Girls	0	1	4	4[2]	3	5
Even	2	0	1	2	1	0
	6	6	14	14	13	13

Here again we have evidence of superior ability on the part of the boys in the solving of both types of problems.

Further evidence is produced in Tables XI. and XII. The approximate percentages of boys and girls in the three groups are as follows:

(1) Comparison of Age 10 groups

	1 & 2	3 & 4	5 & 6
Boys	8.0	52.0	40.0
Girls	18.4	59.2	22.4

(2) Comparison of Age 11 Groups

	1 & 2	3 & 4	5 & 6
Boys	10.1	54.5	35.4
Girls	13.7	60.3	26.0

The percentage of girls in the "1 and 2" groups is greater than that of the boys for both ages. In the "5 and 6" group, the percentage of boys is higher than that of the girls.

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1 "9" --in 9 of the 14 pairs of average A scores recorded in Table XIII., the boys' scores exceeded the girls' scores;

2 "4" --in 4 instances the girls(B scores were higher than the boys'. (The table for the "1 and 2" group has not been earlier recorded for reasons previously explained.)

Lastly, the correlation coefficients (See Table XV) are higher for the boys' scores than for the girls' scores. This would seem to indicate a greater degree of arithmetical ability on the part of the boys.

The following comparisons between boys' and girls' scores now have been made:

(1) Total correct solutions.

(2) Average scores holding age constant.

(3) Average scores holding I. Q. constant.

(4) Average scores holding both age and I. Q. constant.

(5) Group scores holding age and I. Q. constant.

(6) Distribution of scores on basis of age and I. Q.

(7) Correlation coefficients.

All lines of evidence examined point to one conclusion, that the boys excel in both types of problem solving, although the degree of superiority is not outstanding.

Relation between Problem Solving Ability and Age

It has been apparent from a study of Table IV. that the youngest students obtained the highest average scores. There is a marked tendency toward lower average scores with increase in age, particularly in the B test. This is true only when I. Q. is not taken into consideration.

In Tables VI. and VII. attention has already been drawn to the general increase in problem solving ability with increase in age, when I. Q. is held constant. This increase is apparent in both boys' and girls' scores and in both tests. One girl of 13 years of age with an I. Q. slightly above

normal obtained the highest pair of scores in the entire test, while a boy of 16, with a very subnormal rating, received scores of 7 and 5 on the A and B tests respectively. Undoubtedly, age, with experience, was an overpowering factor in each of these cases.

The influence of age is less marked on the scores of students with low I. Q. rating than on the more intelligent pupils. These findings are further corroborated by the figures in Tables XIII. and XIV. Here the A scores are kept constant by groups, and the influence of age on the B scores is revealed.

Practically all those girls who obtained zero scores on the B test were young in years. Their I. Q. ratings varied from 90 to 128. In this case, age seems unmistakably to have been a direct factor. The boys with zero B scores were all retarded cases with low I. Q.

The correlations previously referred to for the 11 year old students, boys and girls, are much lower than are those of either the 10 or the 12 year old students. The oldest students show the highest correlation between the A and B scores. The explanation here would seem to be that experience favors the oldest students, and overcomes the handicap of lower mentality, whereas a higher degree of intelligence or actual reasoning ability offsets the lack of experience of the youngest group. The 11 year old students are largely of normal I. Q. with less ability than the 10 year old group and less experience than the 12 year old group.

While the favorable influence of age on problem solving ability is quite evident from an examination of the data, nevertheless, as a factor, age does not appear to be as potent as one might have expected.

Relation between Problem Solving Ability and I. Q.

Throughout this investigation the strong influence of I. Q. has been apparent. An increase in I. Q. has almost invariably been paralleled by an increase in scores for both boys and girls, at every age. This is well shown by the summary in Table V. where the supernormal pupils of even the younger ages, have average scores equal to those of the older pupils of lower I. Q. rating. An examination of the scores of the boys and the girls of ages 10, 11 and 12, where numbers are adequate, reveals this rapid increase as one proceeds from the weaker to the stronger pupils. Furthermore, the percentage increase in Test B scores is, in the majority of cases, very much greater than in the A scores. For example, the 12 year old girls of less than 95 I. Q., have average scores on the A and B tests of 3.36 and 2.75 respectively, while the normal girls of the same age have scores of 3.63 and 4.75 respectively. The relation is true for nearly all ages and for both sexes. Table VIII., showing a comparison of average scores on the basis of I. Q., discloses the same finding, the spread between extremes of B scores being greater than that between the extremes of A scores. An examination of the distribution of scores by groups, as given in Tables XI. and XII., bears out this conclusion. Here, regardless of age, the scores of the lower I. Q. divi-

sions are mainly in the "1 and 2", or "3 and 4" groups, while the higher scores are recorded along with the higher mental ratings. If any further corroboration is needed, it is to be found in Tables XIII. and XIV., where the B scores advance rapidly as the mental rating increases. These changes are recorded graphically in Figures 2 and 10.

It would appear that the influence of I. Q. is here clearly established. The scores on Test A have been narrowed down, as a result in all probability, of the influence of teaching, memorizing, etc. The new type of problem, on the other hand, lacks this background of instruction, and forces the pupil to draw upon his or her real problem solving ability. Hence the wide range of B scores. A combination of higher age with higher I. Q. is productive of the best results. (See Tables IV., VI., VII., XI. and XII.) This brings us back to our earlier statement of mental age. It will be recalled that at a mental age of $11\frac{1}{2}$ years there is a marked increase in scores. A period of understanding has arrived, but not before the combined influence of chronological age and mental age has reached this definite mark.

The above conclusions may be summarized briefly as follows: Each of the variables, sex, age and I. Q. is found to have a direct influence on the problem solving ability of Grade V. pupils. The three variables sex, age and I. Q. are effective in the order I. Q., age and sex.

CHAPTER VI

CRITICISMS AND SUGGESTIONS

While, within the limits of its scope, the findings of this investigation have been fairly definite, the writer submits the following criticisms, and suggestions for a continuation of the investigation.

The lack of a complete history of the students, including such factors as health, earlier teaching, length of period of school attendance, etc., has allowed the entrance of these uncontrollable factors, which may cause discrepancies difficult to understand and interpret.

As has been stated, the number of pupils represented at each end of the 9 - 15 period under consideration, has been comparatively small. In some classes the number of cases at these extremes has been practically nil. For this reason it is difficult to draw conclusions in regard to these ages with the required degree of assurance. It would be necessary to draw from possibly 1000 cases of Grade V. pupils in order to get a proper sampling of young and old pupils for the grade.

Again the fact that some of the problems of Test A were mechanically beyond the ability of Grade V. students, made the scores not so high in this test as they would otherwise have been, although the conclusions drawn would possibly be unaffected. For a verification of these findings the writer would suggest a test on problems of the same type as those represented on Test A, but standardized within the range of Grade V. students' mechanical ability.

It would be interesting and profitable to carry this investigation on in other grades, preferably first in Grades IV. and VI., where the earlier and later ages previously referred to would be met with in greater numbers than could be found in Grade V. alone. With several such coherent investigations carried on through the public school grades, one would have comprehensive material with which to compare the varying degrees of influence exerted by sex, age and I. Q. respectively.

If possible of accomplishment, an investigation carried on among subnormal and supernormal students would reveal information helpful in the better understanding of the normal mental age.

Further work might be done in the comparison of the relative problem solving ability of the two sexes, by obtaining added data on the average mental age at which the boys and the girls reach the stage of understanding.

The figures dealing with the correlation between the A and B tests are very interesting, in that the boys' correlation coefficients are consistently higher than those of the girls, but the two sexes show a distinct parallelism with a decided drop at 11 years of age. An extension of this investigation along these lines should be productive of interesting results and would also clear up the writer's difficulty in explaining the above data.

CHAPTER VII

APPLICATION TO EDUCATIONAL METHODS

The results of this investigation would appear to have a direct bearing upon the methods of teaching Grade V. Arithmetic.

The present day tendency in teaching Arithmetic in Grade V. deals with the presenting of problems to be solved by a more or less mechanical method following type questions. The previous four years of public school life have been spent in mastering the four fundamentals of Arithmetic with some slight application to simple problems. In Grade V. the applying of the mechanical processes previously mastered, is carried further. Whether or not the pupils' mental development warrants the procedure as now carried on in our schools, is a question upon which the results of this investigation should throw some light. Teachers have seldom questioned the ability of the pupils to understand the various steps in the process of problem solving, deeming it sufficient for the pupil to be able to follow in order the steps as taught in the types.

Several investigators have partially analysed problem solving difficulties and have presented their findings in short journal articles and bulletins. A number of other investigations have been conducted more recently in this University with results that are decidedly interesting.

The present system of grading places together in a grade, all types of students, boys and girls, young and old, feeble-minded and supernormal, as a result of their having absorbed a certain amount of knowledge, a process in which

the actual ability of the teacher to engrave her lesson on the minds of the pupils is a most decisive factor. As shown in the above results, the pupils' creative ability is of secondary importance to their power to assimilate what is presented to them. The evidence submitted above reflects credit on the teaching ability of Grade V. teachers, but not on the methods they are required to follow.

This brings us face to face with the larger problem: Are educational authorities justified in expecting students of Grade V. ability and intelligence to learn and execute the processes as taught at present, or is some revision of the present course of study desirable? This is a vital question which may require a very considerable amount of investigation before it is finally settled.

Grateful acknowledgments are made to all those who assisted with this investigation, and particularly to Dr. Lazerte for his helpful suggestions and kindly criticisms throughout. Thanks are also due to Mr. W. E. Edmonds for his careful reading of the proof.

Tanner, H.E. C.2

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